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Waste Handling System	210-00C-FH00-00500-000-00B

5. Title

Fuel Handling Facility Worker Dose Assessment

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Environmental and Nuclear Engineering/Radiological Engineering

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☒ Preliminary ☐ Final ☐ Cancelled

8. Notes/Comments:

The calculations contained in this document were developed by Environmental & Nuclear Engineering and are intended solely for the use of Environmental & Nuclear Engineering in its work regarding the Fuel Handling Facility. Yucca Mountain Project personnel from Environmental & Nuclear Engineering should be consulted before use of the calculations for purposes other than those stated herein or use by individuals other than authorized personnel in Environmental & Nuclear Engineering.

A review (AP-2.14Q) is not required since the results of this calculation have no impact on the use of the technical output by other organizations and because this is an initial issue of the calculation.

Attachments	Total Number of Pages
I. LISTING OF COMPUTER FILES	1
II. FUEL HANDLING FACILITY'S GENERAL ARRANGEMENT LEGEND AND GROUND FLOOR PLAN	3
III. COMPACT DISK	N/A

RECORD OF REVISIONS

9. No.	10. Reason For Revision	11. Total # of Pgs.	12. Last Pg. #	13. Originator (Print/Sign/Date)	14. Checker (Print/Sign/Date)	15. QER (Print/Sign/Date)	16. Approved/Accepted (Print/Sign)	17. Date
00A	Initial Issue	29	II-3	A. Achudume SIGNATURE ON FILE 08/04/04	V. Arakali SIGNATURE ON FILE 8/4/04	A.Barnes SIGNATURE ON FILE 8/4/2004	~~A.G. Ogurek~~ SIGNATURE ON FILE	8/9/04
00B	Removal of Assumption 5.10 in OOA due to its inapplicability to the FHF Removal of Table 4-4 in OOA Removal of Equation 4 in 00A General adjustment of Assumptions and Equation numbers due to removal of Assumption 5.10 and Equation 4 from OOA Estimated worker doses in Section 8.1 rounded off to 2 significant figures Editing of Attachment III in "External" worksheet. Total Dose to FHF worker is (External Dose from Cask and WP) + (Dose from Resuspension of Cask Contaminants) + (Dose from continuous access low radiation area)							

CONTENTS

LIST OF TABLES

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LIST OF ACRONYMS

ALARA	As Low As is Reasonably Achievable
BSC	Bechtel SAIC Company, LLC
CEDE	Committed Effective Dose Equivalent
CFR	Code of Federal Regulations
CHF	Canister Handling Facility
CO	Cask Operator
DDE	Deep Dose Equivalent
DOE	United States Department of Energy
DTF	Dry Transfer Facility
GO	Gantry/Crane Operator
FHF	Fuel Handling Facility
HLW	High Level Waste
HP	Health Physics
MGR	Monitored Geological Repository
MSC	MGR Site Specific Cask
NRC	United States Nuclear Regulatory Commission
PCSA	Preclosure Safety Analysis
PWR	Pressurized Water Reactor
SARP	Safety Analysis Report for Packaging
SNF	Spent Nuclear Fuel
SF	Significant Figures
SRTC	Site Rail Transport Car
TEDE	Total Effective Dose Equivalent
TP	Transportation Personnel
TRB	Transporter Receipt Building

UNITS OF MEASURE

Bq	Becquerel
Ci	Curie
ft	Feet
hr	Hour
m	Meter
min	Minutes
mrem	Millirem
rem	Rem
Sv	Sievert
s	Second

1. PURPOSE

The purpose of this design calculation is to estimate radiation doses received by personnel working in the Fuel Handling Facility (FHF) of the Monitored Geological Repository (MGR). The FHF is a surface facility supporting waste handling operations i.e. receive transportation casks, transfer wastes, prepare waste packages, and ship out loaded waste packages and empty casks. The specific scope of work contained in this calculation covers both collective doses and individual worker group doses on an annual basis, and includes the contributions due to external and internal radiation. The results are also limited to normal operations only. Results of this calculation will be used to support the FHF design and License Application.

2. QUALITY ASSURANCE

This document was prepared in accordance with AP-3.12Q, *Design Calculations and Analyses*. Since spent nuclear fuel (SNF) and high level radioactive waste will be handled in the FHF, this document is subject to the requirements of *Quality Assurance Requirements and Description* (DOE 2004, Section 2.2.2A).

3. METHOD

The dose assessment involves calculations of annual individual and collective doses to FHF workers. These occupational doses are defined as the Total Effective Dose Equivalent (TEDE) received by workers involved in FHF operations. The TEDE consists of the sum of the deep-dose equivalent (DDE) from direct exposure (contained sources and airborne radionuclides), and the committed effective dose equivalent (CEDE) from inhalation of airborne radionuclides.

The dose assessments are performed by job function, using time-motion inputs and worker locations. Dose calculations are made on per unit operation, i.e. per transportation cask received and per waste package (WP) delivered using a spreadsheet, and then multiplied by the annual number of casks received and WPs delivered.

The FHF shall be capable of receiving transportation casks, unloading and transferring their contents to waste packages (WP) or MGR Site Specific Casks (MSC), preparing the WPs for disposal, transferring WP to a transporter for sub-surface transfer for disposal and storing the MSCs in the aging area. The worker groups include the following:

- Cask and Waste Receipt
- Transfer Bay Operator
- Health Physics
- Operations Management
- Maintenance Department

3.1 EXTERNAL DOSE CALCULATION METHODOLOGY

The direct external dose, ED_k, received by a worker in group g per operation task, k, is calculated as follows. The dose rates at the locations of each operation task due to external radiation from the contained radiation sources are obtained from shielding calculations.

$$ED_k = \frac{t_k}{60} \times EDR_{dist} \qquad \text{Equation 1}$$

where

ED_k = External dose to a worker in group g per operation task k (mrem/task)
t_k = Duration of exposure per operation task k (minutes)
EDR_{dist} = Dose rate at the worker's distance from the source (mrem/hr)

The annual total external dose, ED_o, to a worker in group g for a series of N different tasks per operation (e.g., cask handling operations) performed in the FHF is calculated as follows:

$$ED_o = \sum_{k=1}^{N} ED_k \times OP \qquad \text{Equation 2}$$

where

ED_o = External dose to a worker in group g per operation consisting of N different tasks (mrem/operation)
OP = Total limiting number of operations, o, per year

The total annual external dose, ED_g, to a worker in a work-crew in group g for all cask and waste package operations is calculated as:

$$ED_g = \frac{ED_o}{crews_g} \qquad \text{Equation 3}$$

where

ED_g = External dose to a worker in group g (mrem/year)
$crews$ = Number of work-crews in group g performing this operation

3.2 INHALATION AND IMMERSION DOSE CALCULATION METHODOLOGY

The annual maximum internal and external doses to a FHF worker due to resuspension of contamination on a transportation cask in the FHF are assumed to be those for the TRB (transporter receipt building, Assumption 5.9) and designated as *ID*.

3.3 TEDE DOSE CALCULATION

The annual total collective effective dose equivalent for each worker category, g, is calculated by summing the component doses from inhalation, immersion and direct external radiation doses.

The total annual effective dose equivalent, $TEDE_g$, to group g for all operations is calculated as:

$$TEDE_g = ID + ED_g$$ Equation 4

where

$TEDE_g$ = Annual effective dose equivalent (TEDE) to a worker in a work-crew in group g (mrem/year)

3.4 ANNUAL CASK AND WASTE PACKAGE OPERATIONS

3.4.1 Annual Number of Transportation Casks Processed

The number of transportation casks processed, OP_C, per year is determined from the minimum of the projected annual number of casks delivered to the FHF (Assumption 5.6) and the estimated FHF processing capacity based on the "limiting" and "expected" task durations (Assumption 5.2). The lower of these two determines the limiting number of transportation cask operations per year. The limiting FHF task is that which has the greatest time duration for completion. Waste package welding is identified to be the limiting task in the worksheet ***"External"*** in the Excel File ***FHF-3.xls*** (Attachment III).

$$OP_C = \min\left(\max\left[CASK_y\right], \frac{T}{P} \times A \right)$$ Equation 5

where

$CASK_y$ = Total casks delivered per year from Assumption 5.6
P = Duration of limiting operation task k (minutes/operation)
T = Units conversion (minutes/year)
A = FHF availability factor (Assumption 5.7) (unitless)

3.4.2 Annual Number of Waste Packages Processed

The number of waste packages processed per year, OP_W, is determined from the number of transportation casks processed using the following equation.

$$OP_W = \frac{AC}{AW} \times OP_C$$ Equation 6

where

AC = Number of SNF assemblies per cask
AW = Number of SNF assemblies per waste package

4. DESIGN INPUTS

This dose assessment involved calculation of annual individual and collective doses received through process tasks performed by the FHF workers. Design inputs include the list of process tasks, exposure times, and dose rates as a function of distance to the worker.

4.1 SOURCES OF RADIATION

4.1.1 Transportation Cask and MSC

The GA-4 legal weight truck cask is representative of all NRC certified transportation casks and the MSC (Assumption 5.1) for this document. The representative GA-4 cask contains four SNF assemblies featuring a source term burnup of 45 GWd/MTU and 15 year cooling time (BSC 2003 [162620], Section 5.1.1.1). Shipment of radioactive material including transportation casks containing the maximum source terms must comply with 10 CFR 71.47(a) limits for the transportation index of 10, i.e. 10 mrem/hr at 1 meter. From BSC 2003 [162620] (Figure 5.3-3), dose rates as a function of distance (shown in Table 4-1) are mapped out for the GA-4 cask inside a concrete wall enclosure. Assumption 5.1 explains that the dose rates in Table 4-1 have been normalized in Table 4-2 to achieve a transportation index of 10 at the greatest dose rate location. A transportation index of 10 is in compliance with 10 CFR 71.47(a) for transport of radioactive material and is representative of the expected dose rate of cask throughput in the FHF. The normalization is done by multiplying 0.346 to the dose rates in Table 4-1 (Assumption 5.1).

Table 4-1 Representative Transportation Cask Dose Rates (mrem/hr)

Horizontal Cask Orientation	m	-5	-1	0	1	5	10	15	20
	10	0.21	0.21	0.21	0.21	0.21	0.21	0.18	0.15
	5	0.52	0.53	0.53	0.52	0.47	0.39	0.32	0.26
	1		1.78	4.7	1.75	1.38	0.92	0.45	0.34
Top	**0**	2.63	4.17	46.4	4.45	2.81	1.12	0.59	0.34
	0.27	4.16	22.09		22.64	3.99	1.29	0.61	0.36
Midplane	**13.7**	4.4	28.25	Cask	28.91	4.28	1.31	0.65	0.37
	0.4	3.96	19.56		21.21	3.75	1.3	0.62	0.36
Bottom	**0**	3.21	8.35	188.9	7.85	2.96	1.14	0.6	0.36
	-1	2.1	3.7	17.34	3.55	2.24	1.01	0.51	0.35
	-5	0.73	1.14	1.27	1.11	0.65	0.53	0.39	0.28
	-10		0.45	0.45	0.44	0.36	0.29	0.23	0.19

Source: BSC 2003 [162620], Figure 5.3-3
Tablenote: (1) Dose includes gamma and neutron contributions.

Table 4-2 Normalized Representative Transportation Cask Dose Rates (mrem/hr)

Horizontal Cask Orientation	m	-5	-1	0	1	5	10	15	20
	10	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.05
	5	0.18	0.18	0.18	0.18	0.16	0.13	0.11	0.09
	1		0.62	1.63	0.61	0.48	0.32	0.16	0.12
Top	**0**	0.91	1.44	**16.05**	1.54	0.97	0.39	0.20	0.12
	0.27	1.44	7.64		7.83	1.38	0.45	0.21	0.12
Midplane	**13.7**	1.52	9.77	**Cask**	10.00	1.48	0.45	0.22	0.13
	0.4	1.37	6.77		7.34	1.30	0.45	0.21	0.12
Bottom	**0**	1.11	2.89	**65.36**	2.72	1.02	0.39	0.21	0.12
	-1	0.73	1.28	6.00	1.23	0.78	0.35	0.18	0.12
	-5	0.25	0.39	0.44	0.38	0.22	0.18	0.13	0.10
	-10		0.16	0.16	0.15	0.12	0.10	0.08	0.07

Tablenote: (1) See Assumption 5.1
(2) Dose includes gamma and neutron contributions.

Per assumption 5.3, workers are assumed to be at 1 m, 5 m, or 10 m from the exterior surfaces of a loaded transportation cask. Dose rates at 1 m, 5 m, and 10 m are calculated by averaging the dose rates at the respective distances from Table 4-2. The average dose rates at the three distances are 4.33, 0.73 and 0.21 mrem/hr for 1 m, 5 m, and 10 m from the cask surface, respectively. The Excel worksheet "*DR-Distance*" included in Attachment III, provides the calculations of the average dose rates. In addition to direct cask exposure, FHF workers will also receive dose during remote operations involving WP, canisters, and bare fuel assemblies (background source radiation). Doraswamy 2004 (Table 4.9.1-2) has a maximum dose rate limit of 0.25 mrem/hr for operating galleries, support rooms, and offices (Low Radiation Areas). The assigned dose rate for workers during remote operations or in a continuous access Low Radiation Area (Assumption 5.10) is 0.05 mrem/hr, i.e. factor of 5 reduction of 0.25 mrem/hr.

4.1.2 Waste Package

Work activities involving loaded waste packages are performed remotely due to extreme radiation dose rates. During such operations, personnel are within shielded areas and are assigned a dose rate of 0.05 mrem/hr (Assumption 5.10).

4.1.3 Canister

Work activities involving loaded canisters are performed remotely due to extreme radiation dose rates. During such operations, personnel are within shielded areas and are assigned a dose rate of 0.05 mrem/hr (Assumption 5.10).

4.1.4 Bare Fuel Assembly

Work activities involving bare fuel assemblies are performed remotely due to extreme radiation exposures. During such operations, personnel are within shielded areas and are assigned a dose rate for of 0.05 mrem/hr (Assumption 5.10).

4.2 PROCESS TASKS AND DURATIONS

Process task definitions for transportation cask and waste package operations within the FHF and their corresponding task durations are presented in Assumption 5.2. Per Assumption 5.2, the "expected" durations are used for the workers' exposure times. These process tasks and corresponding task durations are reproduced in the Excel worksheet that is included in Attachment III.

Process tasks have not been finalized for the FHF at this time, but it is intended that the process steps (Attachment III) be as detailed as possible. The process tasks are input based on Williams 2003 [166771], Table C-1. Although the process steps in Williams 2003 are for the DTF and CHF, it is assumed that the FHF will have similar process steps (Assumption 5.2). The expected exposure distances are based on best reasonable estimates for performance of each function (Assumption 5.3).

4.3 STAFFING AND WORK GROUP CATEGORIES

The staffing requirements and worker group categories are presented in Assumptions 5.4 and 5.5. The worker groups include the following:

- Cask and Waste Receipt
- Transfer Bay Operator
- Health Physics

Per Assumption 5.8, there will be at least 5 work-crews for each of these worker groups.

Although radiation protection (Health Physics) personnel are in a support role and do not perform hands-on activities, per Assumption 5.4, a Health Physics (HP) technician is assumed to be present whenever FHF personnel are performing operations involving exposure to radiation.

In addition, per Assumption 5.5 the following "Not Hands-On" support worker groups are considered:

- Operations Management
- Maintenance Department

Per Assumption 5.5, doses to the Operations Management and Maintenance Department worker groups will be bounded by the doses received by the Cask and Waste Receipt, Transfer Bay Operator, and Health Physics worker groups; therefore, the annual doses to these worker groups will not be calculated.

4.4 INHALATION AND IMMERSION DOSES FROM CASK SURFACE CONTAMINATION

The annual maximum internal and external doses to a worker due to resuspension of contamination on a transportation cask in the TRB are assumed for a worker in the FHF (Assumption 5.9). These doses are presented in Table 4-3 for committed effective dose equivalent (CEDE), deep dose equivalent (DDE), and TEDE.

Table 4-3 Annual TEDE to a Worker per Cask from Resuspension

Dose Component	Annual Dose (mrem/yr)
Inhalation dose (CEDE)	0.132
Submersion dose (DDE)	0.0009
Total dose (TEDE)	0.133

Source: BSC 2003 [162620], page 56

4.5 REGULATIONS

The regulation applicable to worker dose is contained in 10 CFR 20.1201, *Occupational Dose Limits for Adults*:

(a) The licensee shall control the occupational dose to individual adults to the following dose limits:

(1) An annual limit, which is the more limiting of:

(i) The total effective dose equivalent being equal to 5 rems;

or

(ii) The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems.

(2) The annual limits to the lens of the eye, to the skin, and to the extremities, which are:

(i) A lens dose equivalent of 15 rems, and

(ii) A shallow-dose equivalent of 50 rems to the skin or to any extremity.

4.6 ALARA DESIGN GOALS

The ALARA design goal for individual radiation worker dose is to minimize the number of individuals that have the potential of receiving more than 500 mrem/yr TEDE. This ALARA goal is 10 percent of the annual TEDE limit in 10 CFR 20.1201, and includes both internal and external exposures (Doraswamy 2004, Section 4.9.3.3).

5. ASSUMPTIONS

5.1 The radiation dose rate distribution around a GA-4 cask is assumed to be representative of that for other NRC-certified casks. Since all transportation casks must meet the external radiation standards for radioactive shipment as specified in 10 CFR 71.47, the GA-4 cask dose rates have been normalized to obtain a transportation index of 10 i.e. dose rate maximum of 10 mrem/hr at 1 meter.

Rationale: Dose rates used in this document were calculated with source terms and cask design obtained from the GA-4 Cask Safety Analysis Report for Packaging (SARP) (General Atomics 1998, p. 5.2-5–5.2-7 and p. 5.3-2–5.3-3) as described in BSC 2003 [162620] (Assumption 3.4 and Section 5.3.1). GA-4 PWR spent fuel assembly specifies source terms for the various enrichments, burnups, and cooling times. Further, the GA-4 cask has been licensed and certified to carry this Spent Nuclear Fuel (SNF) content (General Atomics 1998).

The dose rate distribution in Table 4-1 has a maximum dose rate of 188.9 mrem/hr on the external surface and 28.91 mrem/hr at 1 meter. However, these do not represent average dose rates of normal expectancy from the transportation cask throughput. The GA-4 source term dose rates are therefore normalized by a factor of 0.346, i.e. 10/28.91, since the cask dose rate is limited to 10 mrem/hr at 1 meter. An appropriate estimate of dose map and anticipated doses is thereby created.

Usage: This assumption is used in Section 7.1.1 and summarized in Tables 4-1 and 4-2.

5.2 The assumed operation process steps and durations that the FHF workers are exposed to radiation are based on the "expected" durations listed in Williams 2003 ([DIRS 166771], Table C-1). The steps and durations for processing empty casks in the Canister Handling Facility (CHF) in Williams 2003 ([DIRS 166771], Table C-5) are also assumed for the FHF.

Rationale: The operation process steps and durations are necessary information for determination of external and internal doses in the FHF. Although process steps in Williams 2003 (Table C-1 and C-5) are for the Dry Transfer Facility (DTF) and Canister Handling Facility (CHF), many process steps in the FHF are similar. This information on waste handling steps and durations represents reasonable estimates and is suitable for this preliminary calculation of an early design of the FHF.

Usage: This assumption is used in Sections 3.4.1, 4.2, and 7.1.3.

5.3 Worker locations for cask preparation operations in the FHF are categorized in terms of distances from the transportation cask surface. The distances are estimated from the most likely worker locations to perform the specific tasks for the cask preparation operations. In general, for hands-on activities (e.g., swipes for surface contamination sampling), the worker is assumed to be 1 meter from the cask. For processing tasks that are not hands-on but require the worker's presence in the area, the worker is assumed to be standing at a reasonable distance from the cask. For processing transportation casks in the FHF, workers are assumed to be at one of the three distances, 1 m, 5 m, and 10 m, from the exterior surfaces of a transportation cask.

Rationale: Based on ALARA principles it is expected that workers will use distance as much as possible to reduce their radiation doses. As such they are expected to move to a reasonably distant location when not specifically required by a job function to be proximate to the cask. The approximate worker locations for the required cask preparation operations in the FHF are summarized in Attachment III (*DR-Distance worksheet*).

Usage: This assumption is used in Section 4.1.1 and 4.2.

5.4 A HP technician is assumed to be present whenever FHF workers are performing operations involving exposure to radiation.

Rationale: The report Mouette 2003 ([DIRS 167067], Section 2.3) states: "HP personnel support the day-to-day operation and processing activities. HP's are within close proximity to operators and work side-by-side. Every activity is surveyed and analyzed for radiological monitoring."

Usage: This assumption is used in Section 4.3.

5.5 It is assumed that the doses to Operations Management and Maintenance Department worker groups will be bounded by the doses received by the Cask and Waste Receipt, Transfer Bay Operator, and Health Physics worker groups.

Rationale: The report Mouette 2003 ([DIRS 167067], Section 2.3) identifies the Operations Management and Maintenance Department worker groups as being support personnel that are "Not Hands-On". The personnel will generally be located in continuously accessible, low radiation areas that are well shielded from the major radiation sources.

Usage: This assumption is used in Sections 4.3 and 8.1.

5.6 The total number of transportation casks that will be shipped to the repository annually is assumed to be 507 (BSC 2003 [DIRS 165990], Table 16).

Rationale: The actual number of processed casks will be the minimum of the projected annual number of casks delivered to the FHF and the estimated FHF cask processing capacity based on the "expected" task durations (Assumption 5.2). This determines a realistic and reasonable number of commercial transportation casks that the FHF will have to process.

Usage: This assumption is used in Sections 3.4.1 and 7.2.1.

5.7 The FHF is assumed to be in operation 24 hours a day, 7 days a week with a 60% availability factor.

Rationale: Both the 24/7 operations and 60% availability assumptions are obtained from the study Williams 2003 ([DIRS 166771], p. 2). The assumption is reasonable since FHF is a processing facility that performs functions similar to the DTF and CHF. As noted therein, a 60 percent availability factor was determined to be reasonable for a first-of-a-kind design.

Usage: This assumption is used in Sections 3.4.1 and 7.2.1.

5.8 For purposes of determining the annual throughput of transportation casks and waste packages per work-shift, it is assumed that there will be 5 crews of Cask & Waste Receipt Operators, Transfer Bay Operators, and Health Physics technicians.

Rationale: At least three crews are needed to support 24/7. However, three crews would not allow for days off, holidays, vacation or sick leave. Four crews, each working 2,000 hours per year, would provide 8,000 hours per year coverage, which is still less than the number of hours per year available (8,760); therefore, this assumption will over-predict the cask and WP throughputs on each shift, which will result in a conservatively high dose estimate.

Usage: This assumption is used in Sections 4.3 and 7.2.1.

5.9 The annual maximum internal and external doses to a FHF worker due to resuspension of contamination on a transportation cask are assumed to be those for the TRB (BSC 2003 [DIRS 162620], p. 56).

Rationale: The annual maximum total dose due to resuspension is 0.133 mrem. This is less than one percent of the total dose received by any worker (except the quality assurance person) in the TRB (BSC 2003 [DIRS 162620], Table 6.5-1).

Usage: This assumption is used in Sections 3.2 and 4.4.

5.10 A dose rate of 0.05 mrem/hr is assigned to remote operations, continuous access Low Radiation Areas, or operations involving no source in the FHF.

Rationale: Doraswamy 2004 (Table 4.9.1-2) has a maximum dose rate limit of 0.25 mrem/hr for operating galleries, support rooms, and offices (Low Radiation Areas). A factor of 5 reduction to this dose rate is deemed a reasonable estimate of annual average dose rates encountered in a continuous access Low Radiation Area.

Usage: This assumption is used in Sections 4.1.1, 4.1.2, 4.1.3, 4.1.4, 7.1.4 and 7.1.5.

6. USE OF SOFTWARE

6.1 ELECTRONIC MANAGEMENT OF INFORMATION

No software subject to verification under LP-SI.11Q-BSC, *Software Management*, was used in this design calculation.

6.1.1 COMMERCIAL OFF-THE-SHELF SOFTWARE

Only commercial off-the-shelf software was used in this calculation.

6.1.2 MICROSOFT EXCEL 97 SR-2

- Title: Excel.
- Version/Revision Number: Microsoft® Excel 97 SR-2.

- This software is installed on a personal computer running Microsoft Windows 2000 with CPU Number 501139.

Standard functions of Microsoft Excel for Windows, Version 97 SR-2, are used in this calculation to display results graphically or in tabular form and to perform the mathematical operations in Attachment III. The user-defined formulas, inputs, and results are documented in sufficient detail to allow an independent repetition of computations. Thus, Microsoft Excel is an exempt software product according to Section 2.1.6 of the procedure LP-SI.11Q-BSC. The Excel spreadsheets are shown in Attachment III.

7. CALCULATIONS

Dose assessment calculations are performed using time-motion inputs and dose rates calculated at FHF worker locations for cask and waste package processing operations. Dose calculations are made per unit operation, i.e., per transportation cask received and then multiplied by the annual number of casks received. The dose assessment calculates annual individual worker doses including contributions from external (i.e., direct) radiation and from inhalation of airborne radioactivity.

External radiation doses are calculated in Sections 7.1 through 7.3. Section 7.1 covers the calculation of external doses to FHF workers by task of the operation process. Section 7.2 determines annual casks and waste packages processed by each work crew. Section 7.3 determines the annual external dose of each work crew. Section 7.4 determines the annual inhalation and immersion doses due to resuspension of radioactive contamination on transportation casks. The total effective dose equivalent (TEDE) is calculated in section 7.5 by summing the component doses from inhalation, submersion and direct external radiation doses.

7.1 EXTERNAL RADIATION DOSE BY TASK

This section discusses the calculation of doses to FHF workers due to external radiation during operations to process a single transportation cask and a single waste package on a task-by-task basis.

7.1.1 Dose Rates Near Loaded Transportation Cask

Per Assumption 5.1, the radiation dose rate distribution around a GA-4 cask is assumed to be representative of that for other NRC-certified casks. Per Section 4.1.1, workers are at 1 m, 5 m, or 10 m from the exterior surfaces of a loaded transportation cask. Dose rates at 1 m, 5 m, and 10 m are calculated by averaging the dose rates at the respective distances. The normalized average dose rates at the three distances are 4.33, 0.73, and 0.21 mrem/hr for 1 m, 5 m, and 10 m from the cask surface, respectively. The average distance from the cask surface of each worker performing each task is estimated to be one of the three values, and the corresponding dose rate is assigned. The worksheet "***DR-Distance***" of Excel file ***FHF-3.xls,*** in Attachment III, provides the calculations of the average dose rates for each distance. The worksheet "***External***" in the same Excel file provides detail of the process steps, durations and their associated dose rate calculated for each worker.

7.1.2 Doses due to Loaded Cask Operations

Cask & Waste Receipt Operators and Health Physics personnel will be present during handling of loaded casks. The basis activity of a Cask & Waste Receipt Operator is hands-on operation while the

basic activity of Health Physics personnel is local observation, except for vent gas sampling and survey of cask surface.

External doses to workers engaged in cask handling operations are calculated in the "***External***" worksheet of Attachment III at each process task using Equation 1. The following example calculations validate the spreadsheet attachment.

Disengage the Front Impact Limiters by Cask/WP Receipt Operator

This task is performed from a distance of approximately 1m, because the activity is a hands-on procedure. From Section 4.1, the average dose rate at 1 meter from the cask is 4.33 mrem/hr. The operation has an "expected" duration of 10 minutes. Thus, using Equation 1,

$$ED_k = \frac{t_k}{60} \times EDR_{dist} = \frac{10(\text{min})}{60\left(\text{min}/_{hr}\right)} \times 4.33\left(mrem/_{hr}\right) = 0.72 mrem$$

This is the value shown in cell F18 of the spreadsheet.

The calculated external doses for processing a loaded cask are 26.08 and 6.55 mrem for Cask & Waste Receipt Operators and Health Physics personnel, respectively. The time to process a loaded cask is 870 min. The calculation is performed in the "***External***" worksheet of Excel file ***FHF-3.xls***.

7.1.3 Doses due to Empty Cask Handling Operations

Removal of the spent fuel assemblies from the cask and transfer to the waste package is conducted remotely; therefore, the Cask & Waste Receipt Operators and Health Physics technicians will not be present in the FHF Transfer Bay, so no direct dose will be incurred. Following spent fuel assembly transfer to the waste package, additional hands-on activities will be conducted associated with closure of the empty cask and removal of the cask from the FHF building.

Per Assumption 5.2, the steps and durations for processing empty casks in the CHF are assumed to be applicable for the FHF. The steps and durations for processing an empty cask and dose calculation are provided in the worksheet "***EmptyCask***" of the Excel file ***FHF-3.xls***. The external doses for processing an empty cask are 0.48 mrem both for a Cask & Waste Receipt Operator and Health Physics personnel. The time to process an empty cask is 580 min.

7.1.4 Doses due to Handling of Waste Package

The operation to receive and prepare an empty waste package for waste transfer is carried out without any contained sources in the vicinity. The operation to return a loaded waste package is done remotely. Therefore, the dose rate to which the Cask & Waste Receipt Operator and HP tech would be exposed during these operations is taken to be 0.05 mrem/hr (Assumption 5.10).

The steps and durations for processing an empty waste package and dose calculation are provided in the worksheet "***External***" of the Excel file ***FHF-3.xls***. The external doses for processing an empty waste

package are 1.20 mrem for both the Cask & Waste Receipt Operator and Health Physics personnel, respectively. The time to process a waste package is 1450 min.

7.1.5 Doses to Transfer Bay Operators

The Transfer Bay Operators are defined as the operators working in the Operating Gallery and Gas Sampling Station. This worker group is responsible for conducting and observing remote operations in the Transfer Bay, Closure Cell, and other processing areas. They are generally located in continuously accessible, low radiation areas that are well shielded from the major radiation sources.

The annual dose to the Remote Operators is based on continuous occupancy, 2000 hrs/year, in the low radiation operating galleries. Per Assumption 5.10, 0.05 mrem/hr is assigned to the Transfer Bay operator (Remote Operator). Thus the annual dose to a Transfer Bay operator is estimated as 2000 hrs/year x 0.05 mrem/hr = 100 mrem/year.

7.2 ANNUAL CASKS AND WASTE PACKAGES PROCESSED PER WORK-CREW

7.2.1 Annual Number of Transportation Casks Processed per Work-Crew

The average number of transportation casks processed annually by each work-crew is the total number of transportation casks that will be handled annually in the FHF divided by the number of work-crews performing those operations.

- **Annual Number of Transportation Casks Processed**

The number of transportation casks processed, OP_C, per year is determined from the methodology in Section 3.4.1 based on the minimum of the maximum number of casks delivered and the maximum FHF cask processing rate per year.

$$OP_C = \min\left(\max\left[CASK_y\right], \frac{T}{P} \times A \right) \qquad \text{Equation 5}$$

where

$CASK_y$	=	Total casks delivered per year from Assumption 5.6
P	=	Duration of limiting operation task k (minutes/operation)
T	=	Units conversion (minutes/year)
A	=	FHF availability factor (Assumption 5.7) (unitless)
T	=	Units conversion (minutes/year)

Per Assumption 5.6, the maximum annual number of casks delivered is 507.

The cask throughput is limited by the duration of the longest process step within the FHF. The longest process step is the welding of a loaded waste package, which is 2516 minutes.

This processing duration is divided into the number of minutes in a year (365) and multiplied by the facility availability factor of 60 percent (Assumption 5.7) to obtain the maximum FHF cask processing rate per year.

$$\frac{T}{P} \times A = \frac{\left(60\,\text{min}/hr \times 24\,hr/day \times 365\,{}^{day}/_{yr}\right)}{2516\,(\text{min})} \times 60\% = 126 \text{ (125.3 conservatively rounded off to 126)}$$

Therefore, the maximum number of transportation casks processed per year, OP_C , is 126, i.e., the minimum of 507 and 126.

- **Annual Number of Transportation Casks Processed per Work-Crew**

The annual number of transportation casks processed per work-crew is OP_C divided by the number of work crews (5 crews, per Assumption 5.8). Thus, a work-crew will process an estimated annual average of 26 casks (i.e. 126/5).

7.2.2 Annual Number of Waste Packages Processed per Work-Crew

The average number of waste packages processed annually by each work-crew is the total number of waste packages that will be handled annually in the FHF divided by the number of work-crews performing those operations.

- **Annual Number of Waste Packages Processed**

The number of waste packages processed, OP_W, per year is determined from the methodology in Section 3.4.2.

$$OP_W = \frac{AC}{AW} \times OP_C \qquad \text{Equation 6}$$

where

AC	=	Number of SNF assemblies per cask
AW	=	Number of SNF assemblies per waste package

The maximum number of waste packages processed annually in the FHF is determined from the number of processed casks and amount of SNF per cask. There is an average of 22 PWR SNF assemblies per cask while a PWR waste package can hold 21 SNF assemblies. Therefor, the annual number of processed casks is

$$\frac{AC}{AW} \times OP_C = \frac{(22\,assemblies\,/\,cask)}{21\,assemblies\,/\,WP} \times 126 = 132$$

Therefore, the maximum number of waste packages processed per year, OP_W , is 132.

- **Annual Number of Waste Packages Processed per Work-Crew**

The annual number of waste packages processed per work-crew is OP_W divided by the number of work crews (5 crews, per Assumption 5.8). Thus, a work-crew will process an estimated annual average of 27 waste packages (i.e., 132/5).

7.3 ANNUAL EXTERNAL RADIATION DOSES

The doses incurred by the worker groups – Cask & Waste Receipt Operator and Health Physics technician – includes exposure during manual cask and waste package processing activities and exposure during periods between processing tasks. When not performing manual operations on a waste package or cask, the work-crew will remain inside the FHF performing support activities in continuous-access low radiation areas.

7.3.1 Worker Time In Continuous-Access Low Radiation Areas

The time in continuous-access low radiation areas, T_n, is the annual time available, i.e. 40 hrs/week x 50 week/year = 2000 hrs, minus the duration of the limiting FHF process step, T_o (WP welding). Thus,

$$T_o = \frac{2516\left(\text{min}/WP\right)}{60\left(\text{min}/hr\right)} \times 27\left(WP/crew-yr\right) \approx 1132\left(hrs/yr\right)$$

and

$$T_n = 2000\left(hrs/year\right) - T_o = 2000\left(hrs/yr\right) - 1132\left(hrs/yr\right) \approx 868\left(hrs/year\right)$$

7.3.2 Annual External Dose per Work Crew

The total annual external dose, ED_g, to a worker in a work-crew within group g for all cask and waste package operations is:

$$ED_g = ED_C \times NP_C + ED_W \times NP_W + T_n \times DR$$

The resulting annual doses for each worker group, Cask & Waste Receipt Operators and Health Physics technicians are given in Table 7-1. The detail of the calculations for Table 7-1 is provided in the worksheet "***External***" of the Excel file ***FHF-3.xls***.

Table 7-1 Annual Average External Radiation Doses to Workers (mrem)

Parameter	Symbol	Units	Cask & Waste Receipt Operator	Health Physics Technician
Dose per cask	ED_C	mrem/cask	26.56	7.03
Annual casks per crew	NP_C	cask/crew-yr	26	26
Annual dose from cask processing		mrem/yr	690.5	182.8
Dose per WP	ED_W	mrem/WP	1.20	1.20
Annual WP throughput per shift	NP_W	WP/crew-yr	27	27
Annual dose from WP processing		mrem/yr	32.4	32.4
Time in low radiation area	T_n	hrs/yr	868	868
Dose rate in low radiation area	DR	mrem/hr	0.05	0.05
Continuous-Access Low Radiation Dose		mrem/yr	43.39	43.39
Total Annual External Dose		Mrem/yr	**766.46**	**258.69**

7.4 ANNUAL INHALATION AND IMMERSION DOSES

The annual maximum internal and external doses to a worker due to resuspension of cask surface contamination is addressed in Section 4.4. The annual total dose per cask is 0.133 mrem/yr, which is presented in Table 4-3.

7.5 TEDE DOSE CALCULATION

The annual TEDE for each worker category is calculated by summing the component doses from inhalation, submersion, and direct external radiation exposure over all sources. The annual TEDE doses by worker category are summarized in Table 7-2 below.

Table 7-2 Annual TEDE Doses by Worker Category (mrem/yr)

	Symbol	Units	Cask & Waste Receipt	Health Physics
Doses fromFHF Operations				
External Dose	ED_g	mrem/yr	766.46	258.69
Inhalation Dose (CEDE) + Submersion (DDE)	ID_g	mrem/yr	0.13	0.13
Total Annual Doses by Worker Group (2 SF)		mrem/yr	**770**	**260**

Source: Summary from ATTACHMENT III ("External" worksheet)

8. RESULTS AND CONCLUSIONS

The results of this dose assessment calculation are summarized in Table 7-2. The parameters used in the dose calculations are supported by appropriate and conservative input data and assumptions. The calculated worker doses in Table 7-2 represent reasonable maximum results compared with the input used to derive them. The results are therefore suitable for the intended use. The uncertainties in the results are identified primarily by the worker locations and the dose rates they will receive, and by the duration of operations, which are currently not easily quantifiable. However, the selected inputs are judged to be representative of conservative conditions.

Table 7-2 summarizes the results of the dose assessments by worker group and includes dose contributions from contained radiation sources in the transportation cask, waste package, and spent fuel assemblies during processing as well as airborne sources from resuspension of surface contamination.

8.1 COMPARISON TO REGULATIONS AND DESIGN GOALS

The estimated doses to individual Cask and Waste Receipt operators is **770 mrem per year** and to Health Physics technicians is **260 mrem per year**. The annual dose to an individual Remote Operator in continuously accessible, low radiation areas is **100 mrem per year** from Section 7.1.5. Doses to the Cask and Waste Receipt operators and Health Physics technicians bound those of any other worker group, per Assumption 5.5.

These doses are in compliance with the requirements of 10 CFR 20.1201(a)(1)(i) [DIRS 127393] limit of 5000 mrem per year for occupational workers in Section 4.6. However, individual worker doses for the cask operators and the health physicists exceed the ALARA goal to minimize the number of individuals that receive more than 500 mrem per year in Section 4.7.

Collective annual doses for all workers are not determined in this calculation because of lack of detail on the numbers of workers to perform individual tasks and lack of task details for several worker categories: operations management, maintenance, and chemistry support. A collective dose estimate is not necessary to achieve the objectives of this calculation to support the design of the FHF and provide occupational dose estimates for the License Application. The individual worker group dose estimates by work task are sufficient.

8.2 DISCUSSION

One of the secondary uses of the dose assessment is to identify and prioritize FHF design areas that should consider additional ALARA design features to reduce individual worker doses in order to achieve the ALARA goals. The transportation cask processing tasks were identified as the major contributors to the Cask and Waste Receipt operator and Health Physics technician doses. The direct external dose due to cask processing constitutes 90% of the total annual dose received by the Cask and Waste Package Operator and 70% of the total dose received by Health Physics technician.

8.3 RECOMMENDATIONS

The results of the dose assessment presented in this document lead to the following conclusions and recommendations:

- The principal contributor to the worker dose is from the contained source in the transportation cask. Contributions from airborne source are negligible. The cask operator and health physics work groups will receive the highest dose because of their proximity to the cask during cask processing activities in the FHF. The dose to the cask operator work group exceeds the ALARA goal of 500 mrem/yr per worker. It is recommended that further ALARA design considerations be included in the final design to achieve the ALARA goal.

- Dose rates in the vicinity of a transportation cask for this dose assessment are based on an open bed GA-4 legal weight truck transportation cask with PWR spent nuclear fuel and dose rates of 10 mrem/hr at 1 meter. Casks using closed, secured, and sole-use shipments could have higher dose rates up to 1000 mrem/hr on the surface, 200 mrem/hr on the outer vehicle surface and 10 mrem/hr at 2 meters from the vehicle surface. It is recommended that when information on commercial casks, especially rail casks, becomes available, ALARA design features and considerations for cask handling and processing be reviewed, evaluated and included in the final design to achieve the ALARA goal for the selected cask designs and shipment dose rate limits.

9. REFERENCES

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10. LIST OF ATTACHMENTS

ATTACHMENT I: LISTING OF COMPUTER FILES.

ATTACHMENT II: FUEL HANDLING FACILITY'S GENERAL ARRANGEMENT LEGEND AND GROUND FLOOR PLAN.

ATTACHMENT III: FHF-3.xls CD ATTACHMENT

ATTACHMENT I

LISTING OF COMPUTER FILES

Date	Size (Bytes)	File
07/09/2004 02:16p	113,664	FHF-3.xls

ATTACHMENT II

FUEL HANDLING FACILITY'S GENERAL ARRANGEMENT LEGEND AND GROUND FLOOR PLAN

ROOM LEGEND
FUEL HANDLING FACILITY

GROUND FLOOR

1001	ENTRANCE VESTIBULE
1002	PREPARATION ROOM
1003	MAIN TRANSFER ROOM
1004	FUEL TRANSFER BAY #1
1005	FUEL TRANSFER BAY #2
1006	FUEL TRANSFER BAY #3
1007	REMOTE HEPA FILTER ROOM
1008	ELECTRICAL ROOM
1009	GAS SAMPLING ROOM
1010	SECURITY ROOM
1011	COMMUNICATION ROOM
1012	CORRIDOR
1013	WP CLOSURE TRANSFER ROOM
1014	WP CLOSURE TROLLEY ROOM
1015	MAIN TRANSFER OPERATING GALLERY
1016	MAINTENANCE ROOM
1017	CORRIDOR
1018	HVAC SUPPLY AIR HANDLING ROOM
1019	STAIR #1
1020	STAIR #2
1021	STAIR #3
1022	STAIR #4
1023	FRIEGHT VESTIBULE #1
1024	FREIGHT ELEVATOR #1
1025	FREIGHT ELEVATOR LOBBY #1
1026	FREIGHT VESTIBULE #2
1027	FREIGHT ELEVATOR #2
1028	FREIGHT ELEVATOR LOBBY #2
1029	ELEVATOR
1030	ELEVATOR LOBBY
1031	STORAGE ROOM
1032	ELECTRICAL ROOM TRAIN "A"
1033	ELECTRICAL ROOM TRAIN "B"

MEZZANINE PLAN

M001	SECONDARY/TERTIARY HEPA FILTER PLENUM ROOM
M002	NOT USED
M003	AIRLOCK
M004	AIRLOCK
M005	AIRLOCK
M006	AIRLOCK
M007	AIRLOCK

PLAN @ ELEV. + 64'-0"

3001	WP CLOSURE PEERING EQUIPMENT ROOM
3002	NON-CONFINEMENT AHU ROOM
3003	HVAC EXHAUST FAN AREA
3004	CORRIDOR
3005	CORRIDOR

OPERATING FLOOR PLAN

2001	FUEL TRANSFER ROOM
2002	FUEL TRANSFER CONTROL ROOM
2003	PRIMARY CONFINEMENT HEPA FILTER ROOM
2004	CORRIDOR
2005	WP CLOSURE OPERATING GALLERY
2006	WP CLOSURE ROOM
2007	WP CLOSURE ELECTRICAL ROOM
2008	WP CLOSURE SUPPORT ROOM
2009	CORRIDOR
2010	NOT USED
2011	GENERAL OFFICE SPACE SUPPORT
2012	NOT USED
2013	MAIN TRANSFER MAINTENANCE ROOM
2014	GAS SAMPLING ROOM
2015	HP SUPERVISOR ROOM

DRAWING INDEX
FUEL HANDLING FACILITY
GENERAL ARRANGEMENT

210-P10-FH00-00101-000-00A	LEGEND & GENERAL NOTES
210-P10-FH00-00102-000-00A	GROUND FLOOR PLAN
210-P10-FH00-00103-000-00A	OPERATING FLOOR PLAN
210-P10-FH00-00104-000-00A	MEZZANINE PLAN
210-P10-FH00-00105-000-00A	PLAN @ ELEV +64'-0"
210-P10-FH00-00106-000-00A	PLAN @ ELEV +84'-0"
210-P10-FH00-00107-000-00A	ROOF PLAN
210-P10-FH00-00108-000-00A	SECTION A
210-P10-FH00-00109-000-00A	SECTION B
210-P10-FH00-00110-000-00A	SECTION C & D
210-P10-FH00-00111-000-00A	SECTION E & F
210-P10-FH00-00112-000-00A	SPARE - NOT USED

GENERAL NOTES:

1. ALL FLOOR ELEVATIONS ARE NOMINAL.
   GROUND FLOOR ELEVATION SET AT TOC 0'-0".
   FINAL ELEVATIONS TO BE DETERMINED AS DESIGN DEVELOPS.
2. ABBREVIATIONS AND ACRONYMS:
   AUX = AUXILIARY
   DECON = DECONTAMINATION
   DPC = DUAL PURPOSE CANISTER
   EL = ELEVATION
   ELEC = ELECTRICAL
   EQUIP = EQUIPMENT
   FHF = FUEL HANDLING FACILITY
   GL = GIRT LINE
   HEPA = HIGH-EFFICIENCY PARTICULATE AIR
   HVAC = HEATING, VENTILATION AND AIR-CONDITIONING
   INSTR = INSTRUMENT
   LLW = LOW LEVEL WASTE
   LWT = LEGAL WEIGHT TRUCK
   MCC = MOTOR CONTROL CENTER
   MGR = MONITORED GEOLOGIC REPOSITORY
   MSC = MGR SITE SPECIFIC CASK
   OS = OUTSIDE
   OWT = OVERWEIGHT TRUCK
   PREP = PREPARATION
   RB = REMEDIATION BUILDING
   RF = REMEDIATION FACILITY
   SNF = SPENT NUCLEAR FUEL
   SRTC = SITE RAIL TRANSFER CART
   TOC = TOP OF CONCRETE
   TOG = TOP OF GRATING
   TOR = TOP OF RAIL
   TOS = TOP OF STEEL
   TYP = TYPICAL
   UNO = UNLESS NOTED OTHERWISE
   WP = WASTE PACKAGE
   # = NUMBER
3. GENERAL ARRANGEMENTS DO NOT DEFINE THE SAFETY CATEGORIES OF THE STRUCTURES, SYSTEMS, AND COMPONENTS. THEREFORE FLAGS AND BOUNDARIES ARE NOT DEFINED.
4. CONCRETE WALL THICKNESSES SHOWN ARE BASED ON THE MORE STRINGENT REQUIREMENTS OF EITHER THE SHIELDING OR STRUCTURAL SEISMIC CALCULATIONS. ALL THICKNESSES ARE NOMINAL AND SUBJECT TO CHANGE AS THE DESIGN DEVELOPS.
5. FOR WALL, SLAB, AND ROOF THICKNESS SEE DRAWINGS:
   210-DB0-FH00-00101-000
   210-DB0-FH00-00201-000
   210-DB0-FH00-00301-000
   210-DB0-FH00-00401-000
   210-DB0-FH00-00501-000
   210-DB0-FH00-00601-000
   210-DB0-FH00-00701-000
   210-DB0-FH00-00801-000
6. FOR STRUCTURAL STEEL COLUMNS, FLOOR, AND ROOF FRAMING SEE DRAWINGS:
   210-SS0-FH00-00101-000
   210-SS0-FH00-00201-000
   210-SS0-FH00-00301-000
7. HVAC DUCTWORK NOT SHOWN ON GENERAL ARRANGEMENTS FOR CLARITY.

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DRAWING LEGEND:

- MATCH LINE
- GRID LINE
- FLOOR GRATING
- PARTITION WALL SECTION
- CONCRETE SECTION
- OVERHEAD CRANE HOOK LIMITS
- (XXXX) ROOM/AREA NUMBER
- FUTURE EQUIPMENT/FACILITIES
- GRADE SECTION
- EYE WASH

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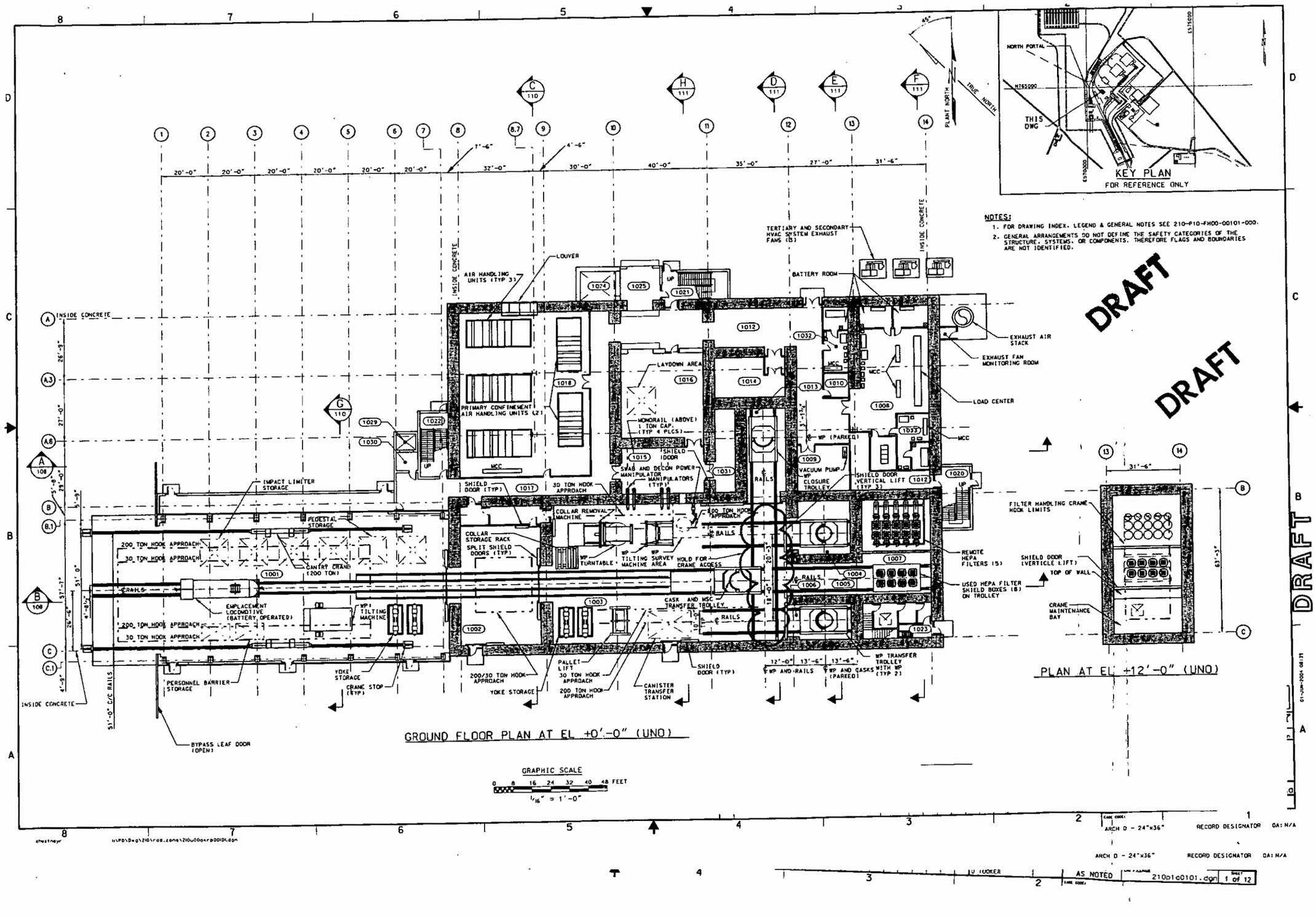
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TRUE NORTH
NOTES:
1. FOR DRAWING INDEX, LEGEND & GENERAL NOTES SEE 210-P10-FH00-00101-000.
2. GENERAL ARRANGEMENTS DO NOT DEFINE THE SAFETY CATEGORIES OF THE STRUCTURE, SYSTEMS, OR COMPONENTS. THEREFORE FLAGS AND BOUNDARIES ARE NOT IDENTIFIED.
DRAFT
INSIDE CONCRETE
LOUVER
AIR HANDLING UNITS (TYP 3)
TERTIARY AND SECONDARY HVAC SYSTEM EXHAUST FANS (3)
BATTERY ROOM
EXHAUST AIR STACK
EXHAUST FAN MONITORING ROOM
LOAD CENTER
LAYDOWN AREA
PRIMARY CONFINEMENT AIR HANDLING UNITS (2)
HONORAIL (ABOVE) 1 TON CAP. (TYP 4 PLCS)
SHIELD DOOR (TYP)
SWAB AND DECON POWER MANIPULATOR MANIPULATORS (TYP 3)
IMPACT LIMITER STORAGE
PEDESTAL STORAGE
COLLAR REMOVAL MACHINE
COLLAR STORAGE RACK
SPLIT SHIELD DOORS (TYP)
WP TURNTABLE
WP TILTING SURVEY MACHINE AREA
HOLD FOR CRANE ACCESS
CANTRY CRANE (200 TON)
EMPLACEMENT LOCOMOTIVE (BATTERY OPERATED)
WP TILTING MACHINE
CASK AND MSC TRANSFER TROLLEY
PERSONNEL BARRIER STORAGE
YOKE STORAGE
CRANE STOP (TYP)
PALLET LIFT
CANISTER TRANSFER STATION
WP TRANSFER TROLLEY WITH WP (TYP 2)
WP AND CASKS (PARKED)
WP (PARKED)
VACUUM PUMP
WP CLOSURE TROLLEY
SHIELD DOOR VERTICAL LIFT (TYP 3)
REMOTE HEPA FILTERS (5)
USED HEPA FILTER SHIELD BOXES (8) ON TROLLEY
FILTER HANDLING CRANE HOOK LIMITS
SHIELD DOOR (VERTICLE LIFT)
TOP OF WALL
CRANE MAINTENANCE BAY
GROUND FLOOR PLAN AT EL +0'-0" (UNO)
PLAN AT EL +12'-0" (UNO)
GRAPHIC SCALE
0 8 16 24 32 40 48 FEET
1/16" = 1'-0"
ARCH D - 24"x36"
RECORD DESIGNATOR
AS NOTED
210p1d0101.dgn
1 of 12